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UTILITY
PATENT APPLICATION
TRANSMITTAL

(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))

Attorney Docket No.	RCA 90,297
First Inventor or Application Identifier	. Voessing, et al.
Title	Method and Encoder for Bit-Rate*
Express Mail Label No.	
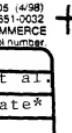
APPLICATION ELEMENTS
See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO:
Assistant Commissioner for Patents
Box Patent Application
Washington, DC 20231

1. ☒ * Fee Transmittal Form (e.g., PTO/SB/17)
(Submit an original and a duplicate for fee processing)

2. ☒ Specification [Total Pages 7]
(preferred arrangement set forth below)
- Descriptive title of the Invention
- Cross References to Related Applications
- Statement Regarding Fed sponsored R & D
- Reference to Microfiche Appendix
- Background of the Invention
- Brief Summary of the Invention
- Brief Description of the Drawings (if filed)
- Detailed Description
- Claim(s)
- Abstract of the Disclosure

3. ☒ Drawing(s) (35 U.S.C. 113) [Total Sheets 1]

4. Oath or Declaration [Total Pages 2]
a. ☒ Newly executed (original or copy)
b. ☐ Copy from a prior application (37 C.F.R. § 1.63(d))
(for continuation/divisional with Box 16 completed)
  i. ☐ DELETION OF INVENTOR(S)
Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).

*NOTE FOR ITEMS 1 & 13: IN ORDER TO BE ENTITLED TO PAY SMALL ENTITY FEES, A SMALL ENTITY STATEMENT IS REQUIRED (37 C.F.R. § 1.27), EXCEPT IF ONE FILED IN A PRIOR APPLICATION IS RELIED UPON (37 C.F.R. § 1.28).

5. ☐ Microfiche Computer Program (Appendix)

6. Nucleotide and/or Amino Acid Sequence Submission
(if applicable, all necessary)
a. ☐ Computer Readable Copy
b. ☐ Paper Copy (identical to computer copy)
c. ☐ Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

7. ☒ Assignment Papers (cover sheet & document(s))
8. ☐ 37 C.F.R.§3.73(b) Statement ☒ Power of (when there is an assignee) Attorney
9. ☐ English Translation Document (if applicable)
10. ☒ Information Disclosure [4] Copies of IDS Statement (IDS)/PTO-1449 Citations
11. ☐ Preliminary Amendment
12. ☒ Return Receipt Postcard (MPEP 503) (Should be specifically itemized)
13. ☐ * Small Entity Statement(s) ☐ Statement filed in prior application. (PTO/SB/09-12) ☐ Status still proper and desired
14. ☒ Certified Copy of Priority Document(s) (if foreign priority is claimed)
15. ☒ Other: Search Report and Priority Documents

16. If a CONTINUING APPLICATION, check appropriate box, and supply the requisite information below and in a preliminary amendment:
☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No: _____/_____
Prior application information: Examiner _____ Group / Art Unit: _____
For CONTINUATION or DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 4b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

17. CORRESPONDENCE ADDRESS

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Signature		Date	31 July 2000

*Saving Encoding of Audio or Signals

Method and encoder for bit-rate saving encoding of audio signals

FIELD OF THE INVENTION

5   The invention relates to a method and an encoder for bit-rate saving encoding of audio signals, especially for encoding of audio signals according to MPEG 1 Audio Layer II.

10

BACKGROUND OF THE INVENTION

The MPEG 1 Audio standard as specified in ISO/IEC 11172-3 defines three operational modes known as Layers I, II and
15   III. Each Layer offers increased compression but also increased encoding complexity, whereby downward compatibility is guaranteed. Therefore, a Layer II decoder can also read a Layer I data stream but no Layer III data stream. Also a Layer III decoder can decode all MPEG 1
20   Audio bit streams, i. e. Layer I to III.

MPEG 1 Audio data compression is based on subband coding. The audio signal is split into 32 subbands of equal width. A quantization is performed using a psychoacoustic model
25   that is adapted to the masking behaviour of the human hearing. Each subband signal is quantized in such a way that the quantization noise introduced by the coding will not exceed the masking curve for that subband. After quantization the samples build – together with the scale
30   factors and further coding information – a frame structure for transmission.

In ISO/IEC 11172-3 two independent psychoacoustic models are defined which can be adapted to any Layer. The output

from these psychoacoustic models is a set of Signal-to-Masking Ratios, SMR_n, for every subband n.

In order to calculate the SMR_n for the psychoacoustic
5   model 2 a Fast Fourier Transformation (FFT) with a length
of 1024 samples is used, which has to run two times per
channel, i. e. four times for a stereo channel.

10   SUMMARY OF THE INVENTION

The invention is based on the object of specifying a
method for bit-rate saving encoding of audio signals using
a psychoacoustical model with reduced computing power.
15   This object is achieved by means of the method specified
in claim 1.

It is a further object of the invention to disclose an
encoder which utilises the inventive method. This object
20   is achieved by the apparatus disclosed in claim 6.

The invention is based upon the following realization. On
the one hand a FFT is a special discrete Fourier
Transformation for which the number of samples has to be a
25   power of two, e.g. 1024 samples. However, on the other
hand the frame length of MPEG 1 Audio Layer II is 1152
samples which is no power of two. This results in the two
runs per channel of the FFT according to prior art.

30   The known formula for a discrete Fourier Transformation,
which calculates for L elements of a data series z(n) the
corresponding L frequency values F(m),

$$F(m) = \frac{1}{L} \sum_{n=0}^{L-1} z(n) \exp(-j2\pi \frac{mn}{L})$$

35

can be transformed first into k partial sums with M
summands each

$$F(m) = \frac{1}{L}\sum_{i=0}^{k-1}\left[\sum_{n=0}^{M-1}z(kn+i)\exp(-j2\pi\frac{m(kn+i)}{L})\right]$$

and finally with L=kM and splitting the exponential
function into

$$F(m) = \frac{1}{k}\sum_{i=0}^{k-1}\left[\frac{1}{M}\sum_{n=0}^{M-1}z(kn+i)\exp(-j2\pi\frac{mn}{L})\right]\exp(-j2\pi\frac{mi}{L}).$$

Therefore, using k subtransformations with a length of
M=2^N allow time effective calculation with Fast Fourier
Transformations, even if L is not a power of two.

In principle, the method for bit-rate saving encoding of
audio signals using a psychoacoustic model, wherein a
Fourier Transformation is performed for calculation of a
minimum masking threshold and wherein L samples of the
audio signal are arranged in a frame for transmission,
consists in the fact that the Fourier Transformation is
performed with a length of L samples by calculating k
subtransformations over 2^N samples with k*2^N=L and fitting
together the results of the k subtransformations.

In this way, the duplicate run per channel is avoided
without lost of information or introduction of errors.
Therefore, the computing power is reduced nearly to the
half. This is especially important for the implementation
on digital signal processors to run in real time.

Although the inventive method is especially advantageous,
if the number k of subtransformations is not a power of 2,

the use of the invention is not restriced to such values
of k.

Advantageously, before fitting together the results of the
5   k subtransformations, these are multiplied with phase
correction factors.

In an advantageous manner, the Fourier Transformation is
performed within the algorithm for the psychoacoustic
10   model 2 of MPEG I Audio Layer II, wherein the frame length
L is 1152 samples.

In an advantageous development k=9 subtransformations with
a length of $M=2^N = 128$ samples are calculated.

15

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments of the invention are described with
20   reference to the figure, which shows schematically the use
of the subtransformations.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

25

Although the encoder is not standardized in ISO/IEC 11172-
3, certain means for encoding such as the estimation of
the masking threshold or quantization are commonly used
and therefore are not described in detail in the
30   following. First of all PCM audio samples with a sampling
frequency of 32, 44.1 or 48 kHz (or with half sample
frequencies of 16, 22.05 or 24 kHz) are fed into the
encoder. A mapping is performed to creat a filtered and
subsampled representation of the input audio stream in the
35   form of so-called subband samples. Each subband signal is

quantized in such a way that the quantization noise
introduced by the coding will not exceed the masking curve
for that subband. In order to control the quantization a
psychoacoustic model is used to calculate the new bit
5   allocation, for MPEG 1 Audio Layer II for three blocks
totaling 36 subband samples corresponding to 1152 input
PCM samples. The calculation is based on the Signal-to-
Masking Ratios, SMR_n, for all the subbands, which makes it
necessary to determine for each subband the maximum signal
10   level and the minimum masking threshold. The minimum
masking threshold is derived by using the inventive method
which is schematically shown in Fig. 1. After windowing
the input PCM samples, samples corresponding to a frame F1
are split and fed to nine subtransformation ST1, …, ST9.
15   Each subtransformation has a length of 128 samples
(9*128=1152) which is the seventh power of 2 ($2^7 = 128$).
After Fast Fourier Transformations of the partial signals
the results of the nine subtransformations are multiplied
with phase correction factors, symbolized by multiplier
20   units M1, …, M9. The phase corrected data are combined,
symbolized by adder unit A and then used for the further
calculation of the psychoacoustic model. The same method
is applied to the following audio samples corresponding to
frames F2, F3 etc.

25

The invention can advantageously be used for encoding of
audio signals according to MPEG 1 Audio Layer 2, but also
applies to the encoding of any other kind of digital data.

30   The invention can be implemented in any kind of encoders
which can be used e.g. for Digital Audio Broadcast (DAB),
Cable and satellite radio/TV or digital recording devices
like DVD-VRs etc.

Patent Claims

WHAT IS CLAIMED, IS

5

1. Method for bit-rate saving encoding of audio signals
using a psychoacoustic model, comprising the steps of:
    performing a Fourier Transformation with a length
of L samples for calculation of a minimum masking
threshold by calculating k subtransformations over 2^N
samples with $k*2^N=L$;

10
    fitting together the results of the k
subtransformations;
    arranging L samples of the audio signal in a frame
for transmission.

15
2. Method according to claim 1, **wherein** the number k of
subtransformations is not a power of 2.

3. Method according to claim 1, **wherein** before fitting
together the results of the k subtransformations, these

20
are multiplied with phase correction factors.

4. Method according to any of claims 1, **wherein** the
Fourier Transformation is performed within the
algorithm for the psychoacoustic model 2 of MPEG I

25
Audio Layer II and wherein the frame length L is 1152
samples.

5. Method according to claim 4, **wherein** k=9

30
subtransformations with a length of $M=2^N = 128$ samples
are calculated.

6. Encoder for performing the method according to claim 1.

Abstract

MPEG 1 Audio data compression is based on subband coding.
A quantization is performed using a psychoacoustic model
which is adapted to the masking behaviour of the human
hearing. Each subband signal is quantized in such a way
that the quantization noise introduced by the coding will
not exceed the masking curve for that subband. In ISO/IEC
11172-3 two independent psychoacoustic models are defined.
The output from these psychoacoustic models is a set of
Signal-to-Masking Ratios, SMR_n, for every subband n. In
order to calculate the SMR_n for the psychoacoustic model 2
according to the invention a Fast Fourier Transformation
is performed with a length of L=1152 samples by
calculating k subtransformations over 2^N samples with
$k*2^N=L$ and fitting together the results of the k
subtransformations.
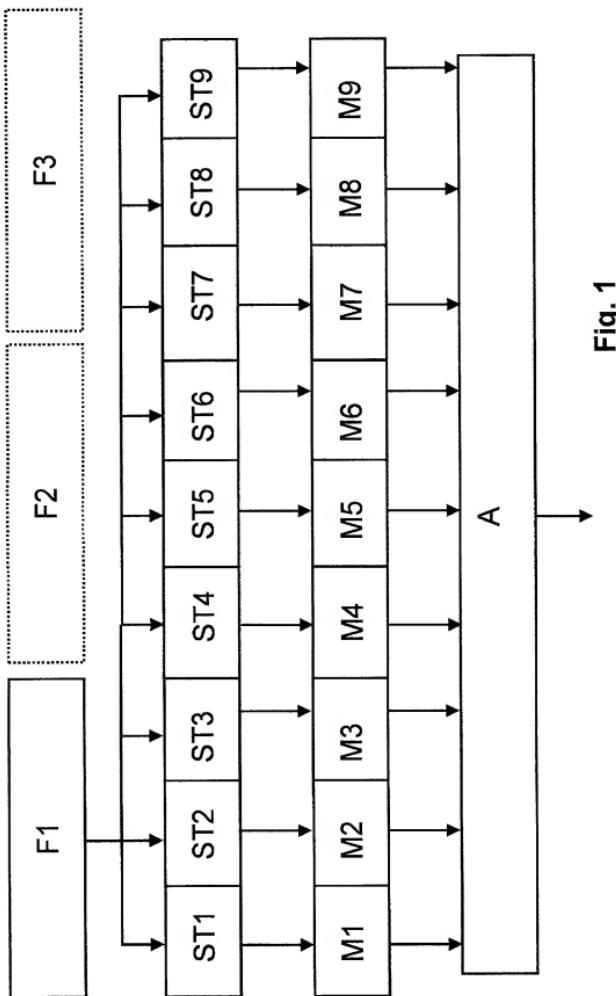
Fig. 1

DECLARATION FOR UNITED STATES PATENT APPLICATION,
POWER OF ATTORNEY, DESIGNATION OF CORRESPONDENCE ADDRESS

As a below named inventor, I hereby declare that my residence, post office address and citizenship are as stated below next to my name, and that I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

METHOD AND ENCODER FOR BIT-RATE SAVING ENCODING OF AUDIO SIGNALS

the specification of which
(CHECK ONE)   (xx)   is attached hereto.
              ( )   was filed on   , Application Serial. No.
                  and was amended on .

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with 37 CFR 1.56(a).

I hereby claim foreign priority benefits under 35 USC 119 of any foreign application(s) for patent, utility model, design or inventor's certificate having a filing date before that of the application(s) on which priority is claimed:

| Prior Foreign Application(s) | | | Priority Claimed | |
Number	Country	Date Filed	Yes	No
99115675.3	EP	August 09, 1999	xx	

I hereby claim the benefit under 35 USC 120 of any US Application(s) listed below, and, insofar as the subject matter of each of the claims of this Application is not disclosed in the prior US application in the manner provided by the first paragraph of 35 USC 112, I acknowledge the duty to disclose information which is material to the examination of this application in accordance with 37 CFR 1.56(a).

Serial No.:   Filed:

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that wilful false statements and the like so made are punishable by fine or imprisonment, or both, under of 18 USC 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

I hereby appoint the following attorneys to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: Joseph S. Tripoli (Reg. No. 26,040), Eric Herrmann (Reg. No. 29,169) and Joseph J. Laks (Reg. No. 27,914) Telephone: (609) 734-9813.

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